**Modern Physics Review**

**A. Know these Scientists and their contributions** (formula and dates are extra!)

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| --- | --- | --- | --- |
| **Contribution** | **Formula** | **Name of Scientist** | **Date** |
| Mathematically Discovered electromagnetic waves, traveling at 3.0x108 m/s |  | Maxwell | 1865 |
| Used an interferometer to detect the luminiferous aether. Null result. |  | Michelson & Morley | 1887 |
| Light is sent in packets called photons | E = hf | Planck | 1900 |
| Studied Photelectric Effect in the Lab |  | Lenard | 1900 |
| Explained Photoelectric Effect | W = hf – Ek  (Work function) | Einstein | 1905 |
| Time dilation, Length contraction, Mass expansion | t = γto  L = Lo/γ  m = γmo | Einstein | 1905 |
| Mass-Energy Equivalence | E = mc2 | Einstein | 1905 |
| Planetary model of Atom |  | Rutherford | 1911 |
| Electron energy shells (orbitals) in atomic model |  | Bohr | 1913 |
| Electrons have spin |  | Stern-Gerlach | 1922 |
| Light has momentum | p = h/λ | Compton | 1923 |
| Particles of matter have wave properties | λ = h/mv | deBroglie | 1924 |
| Probability wave equation |  | Schrodinger | 1926 |
| Uncertainty principle | ΔxΔp > h  ΔtΔE > h | Heisenberg | 1927 |
| Muon Experiment (time dilation and length contraction) |  | Rossi-Hall | 1941 |

**B. True or False?**

|  |  |
| --- | --- |
| I am in a ship traveling at 0.9c. As a result, I notice the ship looks shorter |  |
| An x-ray has a shorter wavelength than blue light. |  |
| Radio waves and X-rays travel at the same speed in a vacuum. |  |
| The faster a particle moves the greater the momentum of the particle |  |
| An electron can never be absolutely still for any length of time. |  |
| A photon has momentum |  |
| A photon has mass |  |
| A blue photon has more momentum than a red photon |  |
| The electron-volt is a unit of energy |  |

**C. Calculation Questions**

1. Convert 20eV to Joules.
2. What is the definition of an electron volt?
3. A photon has a frequency of 300 x 1012 Hz. What is the wavelength of this photon?
4. A photon has an energy of 4.6eV. What is the wavelength of this photon? What “colour” is the photon?
5. Silver has a work function of 4.52 eV. Find the maximum wavelength of a photon that will eject an electron from a plate of silver.
6. What happens if the photon in the previous question has a:
7. longer wavelength?
8. shorter wavelength?
9. UV Light with a wavelength of 3.00 x 102 nm is directed at a metallic surface. Electrons are ejected from the metal with a speed of 2.6 x 105m/s. Calculate the work function of the metal. Answer in eV.
10. Put in order from greatest to least momentum:
11. Gamma ray photon of wavelength 2.4x10-12m.
12. electron of mass 9.11x10-31kg moving at 5.0x106m/s.
13. Elephant of mass 1200kg moving forward at 4.5m/s
14. In the future, a rocket 30m long travels at a cruising speed of 0.5c. For a passenger on the rocket, the trip takes 20 minutes.
15. How long does the trip take according to Earth time?
16. How long is the rocket according to observers on Earth as the rocket goes by?
17. How far did the rocket travel?
18. How far did the trip appear to the passengers?
19. Summarize the trip as observed by passenger and observers on Earth.
20. I boil 750ml of water by adding 3.0MJ of energy. How much does the mass of the water increase?
21. A substance has a half-life of 5.0s. A lab has a 800mg sample of the substance. How much will be left after exactly 1 minute?
22. The sample in the previous question is raining down on us from the upper atmosphere at 0.9c.
23. According to someone on the earth’s surface, what is the half life of the substance?
24. How much is left after 1 minute?
25. An electron sits in the lowest shell of a hydrogen atom. The radius of the shell is 5.29x10-11 m. The electron is hit by a photon and jumps to the second shell, of radius 2.0x10-10m.
26. What is the electric potential of the first shell (include the sign)?
27. What is the electric potential of the second shell?
28. What is the change in electric potential energy of the jump (include sign)? (this is a very simple calculation - don’t over do it!) Is the electric potential energy of the electron increased or decreased?
29. Where does this energy come from?
30. What is the wavelength of the photon? What “colour” is this?
31. An electron and a positron (same particle with a positive charge) move toward each other at a slow speed. When they collide they annihilate and two gamma ray photons are emitted at 180o from each other.
32. Why are two photons needed?
33. Find the wavelength of the photons.
34. An x-ray photon of wavelength 5.6nm strikes a stationary electron. The electron absorbs the photon and recoils at a velocity of 8.8x104 m/s [60oCCW from the original path of the x-ray]. The electron emits a secondary photon. Find:
35. the wavelength of the secondary photon.
36. the angle of the secondary photon’s trajectory.

**D. Thinking Questions - answer in point form.**

1. What is light, according to a) classical theory b) quantum theory.
2. How do you create:
3. radio waves b) microwaves c) visible light waves d) x-rays
4. What is polarization and how can you demonstrate it with a radio?
5. Explain why electrical appliances can emit red light (like a stove top) or white light (like a light bulb) but never green light.
6. Unlike a conventional light bulb, an LED is able to create a single pure colour (such as green). Why is this?
7. Why does a 6V flashlight not produce X-rays?
8. I am wearing a red shirt.

a) Explain why it appears red.

b) What colour will the shirt appear if I shine green light on it? Explain.

1. Use QM to explain why radiowaves will go through a plastic mesh but not a metal mesh.
2. Bohr introduced his model of the atom to explain the spectral signature of the elements. Explain.
3. Rutherford’s gold foil experiment showed that the atom had a massive positive nucleus and tiny negative electrons. He created the planetary model based on this description. He knew his model could not be right, but it was the best description he could come up with. What was wrong about his model?
4. Heisenberg and Schrodinger helped create a better model of the atom. This model solves the problem with the Rutherford-Bohr model. Explain how.
5. What is radioactivity and how does quantum mechanics explain it?
6. In the Rossi-Hall experiment, muons that have an extremely short half-life rain down on us from the upper atmosphere. Based on the short half-life, very few muons should make it to the base of the mountain. When the count is taken at the bottom of the mountain, the count is higher than expected. Use relativity to explain why this is:
7. from the point of view of the scientists on Earth
8. from the point of view of the muon.
9. In the Stern-Gerlach experiment, electrons are found to have spin – as if they are spinning on their axis. This spinning makes the electrons magnetic. Explain why the S-G experiment was difficult to explain classically.